Towards a New Fix: Assessing the new FIX regimes for metals trading*

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Abstract

In 2014, the 'Silver Fix' was formally replaced by a new pricing benchmark (LBMA Silver Price) that would be determined on an electronic platform characterised by greater transparency and auditability. The change principally increased the level of pre-trade transparency for market participants, allowing them to be able to view order submissions throughout the auction process. In this paper we analyse the duration of the price discovery process across two regimes and show that it has become more efficient. We observe a decline in the length of time required to reach the final benchmark price, and also show a reduction in the adjusted returns, volatility, and return predictability of the associated futures contract. We assert that our results are consistent with the Amihud et al. (1997) liquidity externality hypothesis, which prescribes that the more timely and transparent information in one market facilitates better price discovery in the correlated market, thereby improving overall market efficiency.

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1. Introduction

Pricing benchmarks in interest rate, currency, and commodity markets have received a great deal of attention in recent times. Sparked by alleged abuses in the LIBOR in 2008, investigations into precious metal benchmarks have led to similar claims being lodged against key participants involved in the price discovery process. In May 2014, for example, the Financial Conduct Authority (FCA) fined Barclays for inadequate oversight of the gold price setting benchmark, which allowed the bank to manipulate the gold fix.[1] These transgressions highlight a discernible conflict of interest between the principal and agent that persisted due to a lack of oversight. It additionally reveals a lack of transparency around the century-old 'fix' price-setting process, which culminated in participants being able to mislead, and profit from, their customers. In this paper we examine the spillover effects associated with a move to electronic trading in over-the-counter (OTC) precious metal markets.

The wholesale participants of the over-the-counter market for gold, silver, platinum, and palladium (GSPP) have traditionally set the benchmark price of precious metals via a closed-auction process. The fixing process, introduced to the wholesale Silver market in 1897, and other precious metals after this time, allows participants to set a market price which clears any imbalance based on the supply and demand schedules of their clients. The benchmark price not only allows clients to clear their inventory at a fixed price, but also serves as a reference point for hedging and royalty agreements. The change in the price-setting process, which began with Silver in 2014, stems from wide-ranging criticism about the opacity and vulnerability of this system to market abuse. The London Bullion Market Association (LBMA) responded to these criticisms by consulting market participants about possible improvements, before tendering the administration and governance of a new process, on the condition that the new solution would be electronic and auction-based, in order to cater for a larger number of direct participants. Although the precious metals are now being overseen by different parties, with proprietary algorithms being used to determine the clearing price, the nature of the fix process is not materially different between the metals. The new platforms, however, increase the transparency and regulatory auditability of the fixings process. This provides us with an interesting empirical test about whether or not the move to a more transparent wholesale process affects the financially linked derivatives of these commodities.

The effects of a change in transparency on market quality are difficult to gauge for a variety of reasons. Pre-trade transparency has multiple dimensions: a change in transparency, for example, can originate from an exchange allowing participants to view (or hide) broker identities (See Foucault et. al (2007) and Rindi (2008)). Alternatively, it may change because an exchange allows participants to view different levels of the order book. Adjustments in transparency can also be incremental or systematic. Pre-trade transparency changes are also generally quite rare events, with previous empirical work yielding mixed outcomes with respect to their impact on fairness and efficiency (Madhavan et al (2005); Bessembinder et al. (2006); Eom et al. (2007)). From a theoretical standpoint, an increase in transparency may cause a reduction in market maker (participant) rents because opaque markets generally benefit the informed party in bilateral negotiations.[2] Our examination here however, is not based on how the change in transparency affects the wholesale market, but rather whether this change has a spillover effect on correlated financial derivatives.

Amihud et al. (1997) examine the effects of a change in transparency on the Tel Aviv Stock Exchange. Focusing on a select number of securities that were moved over to a more transparent system, the

[1] See FCA final notice 2014 - https://www.fca.org.uk/your-fca/documents/final-notices/2014/barclays-bank-plc

[2] Naik et al. (1999) additionally suggest that improved transparency can improve dealer risk sharing, thereby decreasing inventory costs.

authors' show that improvements in liquidity spilled over to correlated stocks not subject to this change. The authors conclude that an improvement in price discovery in one asset facilitates price discovery in correlated assets; a system of transmission referred to as a *liquidity externality*. Bessembinder et al. (2006) examine the change in transparency of a corporate bond market, and suggest that this liquidity externality is particularly important for corporate bonds, since market participants often estimate the value of non-traded bonds from those that are traded. The authors provide supporting evidence for this effect, showing that trade execution costs fell by approximately 50% for bonds exposed to the more transparent system and 20% for bonds that were not.

The case for increased transparency in OTC commodities markets is however, far from unanimous (Rindi, 2008). Increasing transparency can result in firms exposing their proprietary positions which may impact on total market volume and frequency of traded positions. Additionally, there are potential risks to liquidity stemming from the willingness of market participants to commit liquidity when their positions are detailed to other market participants. Specific transparency requirements for commodities markets may therefore adversely affect market quality. We examine transparency changes in the wholesale commodities market through the shift to electronic trading, and the identification of order submissions in the auction process. While it is generally accepted that the transparency will have an impact on market quality, the vehicle through which this is delivered, and the ultimate outcome are less obvious. In this paper, we empirically add to the debate on optimal market design.

The new fix introduced by Reuters for the silver market appears to have been successful at reducing price leakage around the fix process. We observe a reduction in the adjusted returns and volatility as well as a lower level of anticipation in the associated futures contracts around the final fix price. We also observe a marked decrease in the required time to resolve the fix price, with a 60% fall in the price discovery duration process. The mechanism introduced for gold, however, does not appear to have had a similar positive effect. We find little change in the duration of the fix process, with a slight escalation in the morning process, countered by a small decline in the afternoon price discovery process. We similarly do not observe any change in returns, volatility, and volume of the associated futures contract. We however, caution against reading too much into this result, as the change in process for gold has only recently been overhauled. It is possible that this "transition" period has not reached the new equilibrium conduct as participants seek out new strategies to execute their trading plans. The system introduced for platinum and palladium marginally improves the duration of the price fixing process. Contrary to our expectations, however, we observe behaviour under the new auction mechanism which is much more consistent with information leakage – that is, higher volatility, volume and returns immediately following the start of the fix. Our empirical results reveal that ability of the three new mechanisms to minimise the leakage of the eventual fix price (and to minimise the potential for parties to the fix to profit from their private information) are not equal.

We find evidence of information leakage around the start of the fix for both Silver and Gold markets. No significant leakage is observed for the Platinum and Palladium contracts. This leakage is typified by large, statistically significant spikes in traded volume and volatility immediately following the start of the fix period. These are accompanied by significant positive abnormal returns for informed participants in the first 4-5 minutes after the start of the fix. These abnormal returns deliver an informed trader around 6-10bps, which far exceeds the costs of trading in these highly liquid markets. Further, trades following the start of the fix period are found to accurately predict the fixing price direction in a majority of markets. Our results indicate that the spill over benefits from the OTC metals market to the exchange traded futures markets are significant for the transparent fix mechanism introduced for silver, minimising potentially manipulative conduct. The more opaque gold and platinum/palladium fix mechanisms appear to have either not improved market quality, or made it significantly worse.

The rest of this article is organised as follows: Section 2 describes the institutional detail. Section 3 describes the data and method, including details of the contracts and measures used to assess market quality. Section 4 presents the results and discusses the implications of the change in transparency. Section 5 concludes.

2. Institutional Detail

2.1 Benchmarks and the 'Fix'

An enormous quantity of transactions executed on OTC markets are negotiated on the basis of benchmark prices. Trillions of dollars in loans, for example, are negotiated at a spread to the LIBOR or other such benchmark interbank borrowing rates. In the foreign current market, the WM/Reuters daily fixings are the benchmark reference point for transactions running into the trillions on a daily basis. Benchmarks are also ubiquitously found in commodities markets such as gold, silver, oil, natural gas, and many others. The use of benchmarks in OTC markets is commonplace because they lower search costs by reducing information asymmetries between dealers and market participants (Duffie et al. 2014). Without publication of a reference price, customers would have to request quotes from individual dealers, which would impose significant search costs on these participants. It is for this reason that despite the rapid evolution of international financial markets over the last century that the regime used to set the benchmark price of silver and gold has not changed.

Tracing its origins back to the London Silver Fixing in 1897, and the London Gold Fixing in 1919, the benchmark began with a small number of London bullion dealers meeting on a daily basis to set the price of these precious metals. This pricing process was later expanded into Platinum and Palladium in 1989 through a closed-call telephone system. The wholesale fixing process served as an important reference price, becoming the global benchmark, and used by miners, central banks, jewellers, and also the financial services industry to price derivative contracts and construct hedging agreements. Notwithstanding subtle nuances between the four precious metals, members would declare how much metal they were seeking to purchase or sell on behalf of their clients, in addition to declaring their own proprietary interests.[3] Information about the supply and demand schedules would be relayed back to clients and the chairperson (a role typically rotated between the banks) who would allow the auction to pass through a series of rounds until the volume imbalance fell to within a pre-determined threshold. Once this point was reached, the price would be disseminated to the market and all volume executed at this price.

This efficacy of benchmarks in OTC markets has received greater attention in the literature over the last few years. In the literature, Caminschi (2013) investigate the impact of the London gold fix on two exchange-traded instruments and conclude that information gleaned during the fix process was more than likely disseminated to exchange traded financial markets prior to the formal announcement of a fixed price. Abrantes-Metz (2012) analyse the LIBOR around several periods associated with allegations of market abuse and conclude that the benchmarking process was unlikely to have been systematically manipulated. Despite evidence of a non-random clustering of submitted quotes, the authors show that a predicted benchmark based on highly correlated indicators, is insignificantly different from the actual LIBOR. Atanasov (2015) focus on the settlement pricing procedures of Platinum and Palladium futures contracts, and show that a pricing mechanism which was based on the average of the exchange floor and electronic limit order book trades was artificially manipulated allowing floor counterparties to extract significant economic rents. Despite this, Duffie et al. (2014)

[3] The fix for Gold, Platinum, and Palladium occurs twice-daily. The Silver fix operates once daily.

model the impact of benchmarks on the efficiency of markets characterised by search frictions and show that benchmarks improve market transparency and promote efficiency by reducing information asymmetries.

Following the withdrawal of Deutsche Bank AG as an administrator in the Silver fix process, the last price-fix meeting took place on August 14, 2014. The demise of the fix raised questions in the market about where the new reference price would come from and the LBMA through a consultative process of market participants tendered the process to a number of solutions providers. Following a general consensus for an electronic auction-based platform that provided greater transparency and auditability, the joint proposal of the Chicago Mercantile Exchange (CME) and Thomson Reuters (TR) emerged as the winning proposal.[4] Similar such processes followed for Platinum and Palladium, which would be administered by the London Metals Exchange (LME) and Gold which was to be administered by the Intercontinental Exchange (ICE). The market for Platinum and Palladium and Gold began trading on the 1st December 2014 and the 20th March 2015, respectively.

The new structures represent an electronic solution to the old fix system.[5] The twice daily (with the exception of Silver) auction process that was previously maintained by UK limited liability companies continues to resolve the order flow imbalance with a proprietary pricing mechanism. In each round of the auction participants submit bid and offer orders against a suggested price for the round. If the aggregate bids and offers match within a pre-specified tolerance level then the auction comes to an end. If however, there is a mismatch between aggregate bid and ask volume, there is a subsequent round with an adjusted price. The benchmark price will be the price derived from the final round of an auction. Anonymous bids and offers are now published in real-time with the imbalance calculated and the price updated until the buy and sell orders are matched. The new silver (gold) system proceeds through a series of rounds, each lasting 60 seconds (45 seconds) and under this system agency orders are separated from client orders.[6] In the first live version of the LBMA Gold Price, the benchmark was set at $1,1171.75/oz, following a five round auction.

The most recent changes to the pricing mechanisms of the wholesale GSPP markets attempts to ameliorate a process that was thought to be vulnerable to market abuse and opaque to market participants. With higher levels of pre-trade transparency and a full audit history of principal and agency orders, the change in microstructure of this setting will have implications for the associated financial derivatives markets.

3. Data and Method

3.1 Data Source and Sample Selection

The data used in this study is obtained from the Thompson-Reuters Tick History (TRTH) database. This data comprises of intraday (1-minute interval) updates on the price and volume for the primary futures contracts of each of the precious metals (Gold:GC, Silver:SI, Platinum:PL, Palladium:PA). It includes the high, low, open, close and traded volume per minute. Data on the quotes in the underlying wholesale markets contain: high, low, open and close per minute for each metal (Gold:XAU=, Silver:XAG= ,

[4] The methodology considers the recommendations of the International Organization of Securities Commissions (IOSCO) Principle of Benchmarks. See http://www.iosco.org/library/pubdocs/pdf/IOSCOPD415.pdf

[5] A full description of the LBMA Silver Price benchmark methodology is provided in Appendix A.

[6] Under the LMEs administration, the price for platinum is determined first, followed by the price of palladium.

Platinum:XPT=, Palladium:XPD=). The time and price of the afternoon fix is obtained using the following codes: Gold (XAUFIXPM), Silver (Old:XAGFIX, New: LDNXAG), Platinum (XPTFIX) and Palladium (XPDFIX). A summary of the data and instruments used is provided in Table 2.

<Insert Table 2 >

Our study period extends from the 14th February 2012 to the 30th of April, 2015, a total of six months prior to the introduction of the Silver Fix on the 15th of August 2014, and one month after the introduction of the new Gold Fix on the 20th March 2015. Our period also captures the December 1st, 2014 change in the Platinum and Palladium Fix mechanisms.[7]

In order to determine the duration of each fix, we acquire details about the publication time of the benchmark price and use this information to inform our measure. The end of the fix requires members to reach a price where the imbalance falls within a tolerance level, so the duration of this process can vary widely. Figure 1 contains histograms of the duration of both the old and new fixings on a precious metal basis. The average fixing under the previous regime takes approximately 8-10 minutes depending on the metal, with the majority of fixings concluded within 20 minutes of the start of the auction process. The introduction of the new fix mechanism has had a varying impact on the duration of price setting benchmark. Results for the durations of GSPP are outlined in Table 1. The silver fix has become noticeably shorter, with 50% of the new fixes resolved in one minute and a further 25% resolved within 1-2 minutes. Over 95% of price discovery sessions are now concluded within 3 minutes. The duration of the gold fix however, does not seem to have materially changed; extreme values, however, are encountered less frequently.[8] Platinum and Palladium additionally becomes shorter on average, with the afternoon Platinum (Palladium) sessions, approximately 20% shorter following the implementation of a more transparent pricing process. Despite this, the durations of the platinum and palladium fix are significantly longer than gold or silver.

<Insert Figure 1 >

3.2 Contract Specification

The sample for this study is based on the CME futures contracts for four metals contracts (GSPP). Contract months for a) Gold and Silver include: February, April, June, August and December; b) Platinum: March, June, September and December c) Palladium: January, April, July, and October.[9] These futures contracts were selected because they are the most actively traded futures in their respective categories. This minimises any issue surrounding stale quotes and infrequent trading. The first contract of each maturity month is the nearby contract and the remainder are deferred contracts. The inclusion of multiple contracts, from varying maturities was made to ensure that a representative

[7] A number of metal-days were excluded due to data errors. These include 3/5/12, 13/6/12, 19/7/12, 19/4/13 and 28/4/14 for Silver due to the fix time being prior to the explicit start time, 2/2/15 for Gold due to the fix end occurring 99 minutes after the fix start and 4/3/13, 2/1/14, 20/1/14, 21/1/14, 23/6/14, 24/6/14, 4/11/14, 11/11/14, 20/11/14, 1/12/14, 31/12/14, 2/1/15, 21/1/15 and 31/3/15 for Platinum/Palladium due to the lack of a unique end time.

[8] This could be caused by the fact that at the time of running this test, only 32 observations for gold existed in our sample.

[9] Only the quarterly cycles are used for Platinum and Palladium. Palladium futures follow a January to October quarterly cycle.

cross-sectional sample was obtained of the future markets. We select the near futures contracts for our analysis, which is rolled over to the next nearest-to-maturity contract 30 days prior to expiry. This is primarily driven by trading volume considerations.

May of our precious metals trade on multiple exchanges but we restrict our analysis to the primary exchange. Our contracts are traded on the COMEX, a division of the New York Mercantile Exchange (NYMEX) which was acquired by the CME group in 2008. We use data from the electronic GLOBEX platform and exclude quotes and trades from the open-outcry period.[10] The average execution cost for gold (silver) contracts on the CME are approximately 1-2 (3-6) basis points (Marshall et al (2011).

3.3 *Analysis window, reference intervals and time alignment.*

For the full period of our study we analyse volume, volatility and returns on a daily basis. We focus on the start of the fixing period given the importance placed on this time period in both prior academic literature (eg. Caminschi et al., 2014) and in prior accounting scandals. We analyse a 90-minute window, beginning 30 minutes prior to the fix.

Under the old and new regime, the fix starts and end at the same time every day. For the intraday analysis, t_0 is the one minute period, immediately prior to the start of the fix process. Event times relative to the start of the fix are denoted using $t_i \in [-29, +60]$ by indexing each minute *i* to the start of the fix.

3.4 Measures: Volume, Volatility, Returns, CAR, Predictive value of returns, Regression

3.4.1 Relative Volume

To assess the impact of the fix on trading activity we examine the volume traded in every minute for each futures contract around the analysis window. Given the fix contains concentrates the price discovery process in a very short window, we expect that this information will cause a short-term increase in traded volume. Due to the disparity in trading volumes across different metal contracts, we standardise the volume of each contract to the 30 minutes prior to the fix process. Volume data is taken for each of the futures contracts examined (GC, SI, PL and PA), where $VM_{i,d}$ represents the volume traded in minute *i*, on day *d*. The benchmark level of volume VMB_d and average excess volume $\overline{VM_i}$ across all sample days *D* is computed as follows:

$$VMB_d = \frac{1}{30}\sum_{i=-29}^{0} \ln(VM_{i,d}) \qquad (1)$$

$$\overline{VM_i} = \frac{1}{n(D)}\sum_{d \in D}\left(VM_{i,d} - VMB_d\right) \qquad (2)$$

The benchmark level of trading VMB_d is the average log-transformed volume in the 30-minute interval prior to the start of the fixing on day *d.* Thirty minutes is chosen to capture the relative level of trading on the day that is unrelated to the fix. We use the log transformation to normalize the data, especially

[10] The Tokyo Commodity Exchange (TOCOM) offers liquid contracts in gold and platinum, however are not considered in this study since the majority of exchange traded volume runs through the CME.

in light of the minimum value that volume can take, being 0. This also has the effect of reducing the skewness of the volume data, ensuring the robustness of the t-statistics. As $\ln(VM_{i,d})$ is undefined for zero volume, all $VM_{i,d}$ are set to one, implying one contract was traded. This adjustment does not materially impact any of our results.

3.4.2 Volatility

We calculate the relative volatility for our respective futures contracts, at one minute intervals over the activity window. The Kraus-Satchell (2015) volatility estimator is used to estimate the level of volatility in each minute, denoted $V_{i,d}$, using high and low prices ($H_{i,d}$, $L_{i,d}$) for the interval i on day d.[11] Each minute is then compared to the average volatility during the benchmark period, VB_d being the 30 minutes prior to the beginning of the fix. Volatility for each interval ($V_{i,d}$), benchmark volatility (VB_d), and average excess volatility ($\overline{V_i}$) are defined as:

$$V_{i,d} = \sqrt{\frac{\pi}{8}}\left(ln\left(\frac{H_{i,d}}{L_{i,d}}\right)\right) \tag{4}$$

$$VB_d = \frac{1}{30}\sum_{i=-29}^{0} VM_{i,d} \tag{5}$$

$$\overline{V_i} = \frac{1}{n(D)}\sum_{d\in D}\left(V_{i,d} - VB_d\right) \tag{6}$$

3.4.3 Adjusted Returns

We utilise a modified Ederington and Lee (1995) approach to the construction of adjusted returns. This procedure captures returns which are adjusted for price direction, assuming the "informed" trader knows the future price direction. Our price direction is based on the difference between the spot price of the metal immediately prior to the beginning of the fix ($Spot_{0,d}$) and the subsequent published fix price ($Fix_{0,d}$). If the fix is higher than the spot price at the start of the fixing, the adjustment calculates the value of a long position, whereas if the fix price is below the spot at the start of the fix then returns are inverted, providing the return to a short position. These adjusted returns per interval i are then averaged across all days in our sample to identify the average adjusted return. These average abnormal returns are then standardised to construct cumulative abnormal returns (CAR_i) by removing the return during the benchmark period. Return calculations are as follows:

$$DIR_d = \begin{cases} +1, Fix_d > Spot_d \\ -1, Fix_d < Spot_d \\ \ \ 0, Fix_d = Spot_d \end{cases} \tag{7}$$

$$AR_{i,d} = DIR_d \times \ln\left(\frac{C_{i,d}}{C_{i-1,d}}\right) \tag{8}$$

$$\overline{AR_i} = \frac{1}{n(D)}\sum_{d\in D} AR_{i,d} \tag{9}$$

$$CAR_i = \sum_{n=-29}^{i}\overline{AR_n} - \sum_{n=-29}^{0}\overline{AR_n} \tag{10}$$

[11] The results were reconstructed using the Garman-Klass and Rogers-Satchell estimators for robustness, with no material change in the findings.

3.4.4 Regression

In order to study the impact of the introduction of the new fixing procedures, we examine a number of dependent variables, including volume, volatility, abnormal return and cumulative abnormal return using the following regression:

$$y_{k,d} = \alpha + \beta_1 S_d + \beta_2 P_d + \beta_3 G_d + \sum_{j=1}^{4} \gamma_j Controls_{j,d} + \varepsilon \qquad (11)$$

where $y_{k,d}$ represents our independent variables for k minutes after the start of the fix, $k \in [5,10]$ on day *d*. We represent the staggered changes in the fix regimes using a variety of dummy variables: S_d takes a value of 1 for Silver contracts after the 15th of August 2014 and 0 otherwise, P_d takes a value of 1 for Platinum and Palladium contracts after the 1st of December 2014 and 0 otherwise and G_d takes a value of 1 for Gold contracts after the 20th of March 2015 and 0 otherwise. $Controls$ indicates a variety of control variables, including three metal dummies (one each for silver, gold and platinum, leaving palladium as our base case), and the VIX level for the UK market.

4. Results

In order to determine the impact of the new fix mechanisms results have been generated for each of the metals for both the AM and PM fixes across volume, volatility, abnormal returns and cumulative abnormal returns. Table 2 shows a mixed result depending on the metals. While there is a significant reduction in the volume traded both before and after the silver fix, the rest of the metals exhibit either an increase in volume or no change at all. Both the Gold AM fix and Platinum PM fix see significant increases in volume traded before, during and after the fix. The Platinum AM fix experiences a significant increase in volume during the fix, whilst the Palladium PM fix sees increases in volume from the 5th to the 10th minute, however this likely reflects the time during which the palladium fix is being undertaken, due to the staggered nature of the fix determination of these metals, with Platinum determined first, followed by Palladium.

<Insert Table 2 Here >

Figure 2 illustrates the similarity of the traded volumes both pre and post fix for both silver, gold, whilst a significant increase in the new fix volume for both platinum and palladium is evidenced.

<Insert Figure 2 Here >

As the fix conveys new information to the market (being the clearing price and quantity) the release of this information is expected to cause a reaction in the market. If this information is anticipated by the market, we would expect a much less pronounced reaction at the release, with the reaction instead being spread over the preceding minutes as the new information is impounded into prices. Figure 3 documents the price evolution for the old and new fixes up to the point at which the fix is revealed to the market. The old silver fix sees an uptick in volume beginning around 10 minutes prior to the fix end, increasing rapidly to peak at 1 minute after the end of the fix. The new silver fix, however, sees an uptick begin only 2 minutes prior to the fix, rising rapidly to peak in the minute after the determination of the fix. This conduct is consistent with much less anticipation of the silver fix. By contrast, we do not see any major differences in either of the gold fixes, nor do we see a difference in the traded volumes around the end of the platinum or palladium fixes.

<Insert Figure 3 Here >

Table 3 documents the changes in the volatilities due to the introduction of the new fix mechanisms. Consistent with the increased transparency of the silver fix, we see a significant decline in the before, during and after levels of volatility for the silver contracts. Both the Platinum AM and PM experience significant increases in volatility, consistent with the lower levels of transparency regarding their new fix process. The Palladium PM fix also experiences significant increases in volatility in the after period, consistent with the later determination of the Palladium fix. We see no significant change in either of the gold fixes subsequent to the introduction of the new mechanism.

<Insert Table 3 Here >

Figure 4 documents the evolution of the Kraus-Satchell volatility measure around the beginning of the fix. While slightly lower levels of volatility are observed for the new silver fix, little change is observed for both gold contracts. No discernible change in volatility is observed for either of the platinum nor palladium fixes.

<Insert Figure 4 Here >

Figure 5 examines the volatility of futures contracts surrounding the end of the fix. Consistent with the revelation of new information, we see a significant increase in volatility surrounding the conclusion of the new silver fix. Large spikes in volatility are observed in the gold PM fix 5 minutes prior to the end of the fix, with little change between the old and new fix. The gold AM fix exhibits almost identical volatility evolution in both the old and new fix regimes, increasing significantl exactly around the fix end. Elevated levels of volatility for both platinum and palladium fixes are documented in the 10-15 minutes prior to the end of the fix. Such behaviour is consistent with the revelation of fix information prior to the end of the fix.

<Insert Figure 5 Here >

Table 4 reports the abnormal returns and Table 5 reports the cumulative abnormal returns. We find no significant difference in the CARs nor the ARs subsequent to the introduction of the new fix mechanisms for any metal except for silver. The abnormal returns during the first 5 minutes subsequent to the fix reduce by half, from an average of 1.4bps per minute to 0.7bps points per minute during the new fix. Cumulative abnormal returns during the fix for Silver are also found to be significantly lower, reducing from 7bps to 3bps in the new fix mechanism. This is consistent with the reduced volatility and improvement in transparency. We observe no change in the gold fixes, neither do we find significant differences in the platinum or palladium fixes.

<Insert Table 4 Here >

<Insert Table 5 Here >

Figure 6 examines the abnormal returns surrounding the start of the fix. While the abnormal returns in the new silver regime are significantly lower than previously, the remaining metals exhibit no significant differences as a result of the new fix regime. Both gold fixes see significant abnormal returns around the start of the fix, while platinum and palladium experience t heir abnormal returns in the first 10 minutes subsequent to the fix.

<Insert Figure 6 Here >

Figure 7 documents abnormal returns leading up to the end of the fix. Consistent with the new fix conveying important information, silver sees elevated abnormal returns immediately at the end of the fix, compared to elevated abnormal returns for the prior 5 minutes under the old fix regime. Both the old and new gold fixes exhibit heightened abnormal returns in the 10 minutes prior to the revelation of the fix. No significant difference is observed in the fix-end returns for platinum or palladium.

<Insert Figure 7 Here >

Figure 8 shows the cumulative abnormal returns surrounding the fix start. In comparison to the abnormal return graphs, a clear trend emerges for the CARs. Under the old fix regime, silver contracts responded in the same direction as the eventual fix almost immediately after the start of the fix, moving around 8 basis points on average. In contrast, under the new regime the price moves around 3 basis points in the direction of the eventual fix in the first 5 minutes of trading, implying a much more orderly dissemination of information. Little change is observed due to the new fix for the gold contracts, with the afternoon fix jumping 10 basis points in the first 5 minutes under both mechanisms and the morning fix increasing by 4 basis points over the same period for both the old and new regimes. Turning to palladium, we see a sharp increase in the value of futures contracts around the start of the afternoon fix in both the old and new regimes of approximately 9 basis points in the first 5 minutes, implying no improvement from the new fix. In the AM fix, where the old mechanism previously generated no significant cumulative abnormal returns, under the new fix there is an increase of around 4 basis points in the 10 minutes subsequent to the start, implying some leakage of the eventual fix direction. A similar result is found for the platinum PM fix, with no significant cumulative abnormal returns observed under the old fix, but an increase of around 3 basis points in the first 5 minutes of the new fix, followed by another increase to around 5 basis points in the 20th minute of the fix. No cumulative abnormal returns are observed in either period for the platinum AM fix.

<Insert Figure 8 Here >

Figure 9 examines the cumulative returns to the end of the fix, with silver showing a dramatic improvement. Whilst a significant run-up was observed under the old fix, beginning around 20 minutes prior to the fix and peaking one minute after the fix, the new regime sees the price move only in the last minute, with last minute returns of around 5 basis points. This is consistent with the increased transparency of this mechanism resulting little leakage of the fix direction prior to the conclusion of the fix. In contrast, both the old and new gold fixes exhibit almost identical price run-ups to the fix end, beginning around 10 minutes prior to the dissemination of the fix price. Such run-ups are also observed in the old and new palladium PM fixes, with an 8 basis point increase in the 20 minutes prior to the end of the fix. The palladium AM fix did not exhibit any run-up to the end of the fix under the old regime, however the new fix mechanism has seen an increase of around 3 basis points in the final 10 minutes of the fix. Neither of the platinum fixes exhibit such a runup, with similar characteristics observed in both the pre and post period.

<Insert Figure 9 Here >

In order to provide a more direct comparison of the three different fix mechanisms introduced, we conduct a regression analysis on metal-day panels around both the start and end of the fix. Table 6 reports the results of our analysis for both the first 5 and 10 minutes of the fix. Consistent with our univariate statistics, the silver auction is found to dampen volatility and reduce the AR and CAR in the first minutes of the fix. In contrast, significant increases in volume and volatility are observed for the platinum fix at both the 5 and 10 minute frequency, with higher AR's and CAR's in the first 5 minutes of trading. This is consistent with the increased transparency of the silver market resulting in a more orderly dissemination of information, reducing the volatility of the silver future and decreasing potential profits to informed traders by approximately 4.5 basis points. The lack of transparency around the platinum/palladium auction has instead resulted in an increase in the opening minutes volatility and volume, increasing potential profits for informed traders by around 2.6 basis points. No significant changes are observed for gold, nor for palladium. The result for gold reflects the high degree of similarity between the old and new fixes. The results for palladium are likely due to it being conducted second, meaning our 5-10 minute time frame around the fix start does not capture the period when palladium is being dealt with.

Table 7 examines the returns around the end of the fix. Consistent with the short duration of the silver fix, both volume and volatility to the end of the fix are lower under the new fix. Higher volume and volatility are observed for platinum, along with lower ARs and CARs. This is consistent with the majority of the information contained within the fix having been disseminated to the market prior to the end of the fix. No significant changes are found for gold, with palladium evidencing increased volume and volatility.

5. Conclusion

In 2014, the 'Silver Fix' was formally replaced by a new benchmark for silver that would be determined on an electronic platform characterised by greater transparency and auditability. The change increased the level of pre-trade transparency for market participants allowing them to be able to view order submissions throughout the auction process. In this paper we examine the length of the price discovery process across the two regimes and show that the discovery process has become more efficient. We observe a decline in the length of time required to reach the final benchmark price, and also show a reduction in the adjusted returns and volatility of the associated commodity futures contract. Our results for silver, however, do not seem to hold consistent across other examined precious metals. We show no obvious changes in the gold discovery process and perplexingly find higher levels of leakage and volatility for platinum and palladium. These differences warrant further investigation.

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Appendix:

LBMA Silver Price Discovery Process

The LBMA Silver price is determined using an equilibrium auction that is conducted daily at 12:00:00 London Time. Prior to the first round of the auction, the platform displays a notification to participants that are logged in that the auction is about to begin. The auction platform operator (CME Benchmark Europe Ltd) is responsible for providing the initial auction price which is determined by comparing multiple sources of market data. In each round of the auction, participants are allowed to place one firm order either on the buy or sell side by entering a quantity they would like to execute. Quantities are in units of Lakkhs, where 1 Lakh is 100,000 ounces. When orders are placed in an auction, it is time stamped and displayed on the auction platform audit log for participants to view in real time. Participants are able to see both individual order submissions (but not which registered participant has provided the submission) and the total buy and sell quantity entered. Each participant is also able to amend or cancel their orders prior to the end of the round and are not required to submit to future rounds if they so choose. At the end of each round of the auction, orders on the bid and ask are compared and if the quantity falls below a tolerance value of 3 Lakhs then the auction is closed and the LBMA Silver Price is established. If the difference is greater than this amount then all orders from the previous round are cancelled, and a new round begins with a different price. This process continues until the auction is balanced. The auction platform then matches the orders using a price time priority algorithm until the unfilled quantity on one side is exhausted. Any imbalance is made of all participants who placed orders in the auction process by executing against the participant orders causing the imbalance. A trade report is then created for each participant and counterparty.

LBMA Platinum Price and LBMA Palladium (LPP) Price Discovery Process

The LBMA Platinum and Palladium process commences daily at 9:45am and 2:00pm. The Chair of the price discovery event, who is a member of the Benchmark pricing function, commences the auction when a minimum number of participants (3) have logged into LMEbullion. The opening price is determined by the Chair and this is submitted to LMEbullion. This opening price is determined by the chair using their discretion and expert judgement to analyse relevant sources and/or data feeds as necessary. When the opening price is entered, participants are required to submit in LMEbullion whether they are a buyer or seller and the volume of their orders. If they have no interest at the stated price they are also required to disclose this. Each member participant is allowed to net client order off together with their principal interest to work out the member participant's overall interest. Alternatively, the participant may enter house and client orders separately. Unlike the CME's system for Silver, auction rounds are only resolved when all participants present have entered their interest. At this point LME bullion will enter a 'grace' period for five seconds, where calculations to determine the imbalance of trading volume based on participant interest will occur. If the imbalance calculated is 4,000 troy ounces or less then the proposed price will become the discovered price. In the event that the imbalance amount is higher than the specified threshold, LMEbullion will calculate the proposed price based on a pre-determined price schedule. For example, if the imbalance is between 4001-6001 troy ounces then the price will be adjusted by $US1 dollar, however, if the imbalance is greater than 10,001 troy ounces then the price will be adjusted by $US3 dollars. Where the price direction changes more than six times during the process, specific conditions are in place to resolve the imbalance. Once the LPP prices have been discovered, buy and sell orders may not be altered or withdrawn by participants. LMEBullion will subsequently generate a report stating that the price is the discovered price, which is the final price. Net interest is then matched and all trades are then bilaterally executed between member participants. Once this process has been followed for both platinum and palladium, the price discovery process ends. Price information relating to proposed prices and cumulative buy/sell volumes is published as live data to licensed vendors during the process. LMEBullion will also display a commentary of proposed prices and buy and sell orders on an anonymised basis with relevant timestamps. The discovered price is published at the end of the auction.

LBMA Gold Price Discovery Process

The LBMA Gold Price which replaces the London Gold Fix is administered by the ICE Benchmark Administration (IBA). The IBA auction process is an electronic auction, with the imbalance calculated, and the price adjusted in rounds that are 45 seconds in duration. The auction is run twice daily at 10:30am and 3:00pm London time. It is overseen by a chairperson independent of any firm associated with the auction, appointed by IBA to determine the price for each round and ensure that the prices responds appropriately to market conditions. The auction process is hosted on the WebICE platform which provides real-time order management, separation of client and house orders (though participants can choose to enter a single netted order), and a full audit history. In the auction process, the chairperson sets the starting price and the price for each round. Participants are required to enter buy or sell orders by volume (ounces) and should the net volume of all participants fall within the pre-determined tolerance at the end of a round, the auction will be complete, with all volume tradeable at that price. Netting off orders is processed automatically for participants with all house and client orders, plus any share of the imbalance (which is distributed on a pro-rata basis), contributing to their final net volume. This net volume is then matched against other participants to produce trades with immediate trade confirmations. Once the auction is concluded, the benchmark price is published. During the auction, IBA published auction details live to re-distributors, containing the starting price of each round as well as the final aggregate bid and offer volumes entered in that round.

Table 1

Descriptive statistics on the durations of the fix calculation

This table reports descriptive statistics for the duration of the calculation of the fix mechanisms for Silver, Gold, Platinum and Palladium in minutes. Old Fix reports the period from the 14th February 2012 to the introduction of the fix for each respective metal. The New Fix reports the period from the first day of the new fix mechanism to the 30th of April, 2015. The minimum duration of the fix is reported, along with the first quartile, mean, median, third quartile, maximum and standard deviation. The number of days identifies the number of days in our sample in each of the old/new fix regimes. Each metal which has a morning (AM) and afternoon (PM) fix have results reported separately for each.

	Silver		**Gold**				**Palladium**				**Platinum**			
	PM		**Am**		**Pm**		**Am**		**Pm**		**Am**		**Pm**	
	New	**Old**	**New**	**Old**	**New**	**Old**	**New**	**Old**	**New**	**Old**	**New**	**Old**	**New**	**Old**
Minimum	0.5	0.5	1	0.5	1	0.5	6	7	6	5	0.5	7	5	5
Q1	1	1	2	1	2	2	10	13	9.5	14	9	13	9	14
Mean	1.08	2.7	3.31	2.72	3.53	4.03	16.73	18.82	15.65	19.46	14.83	18.83	15.07	19.47
Median	1	2	3	2	3	3	15	16	14	18	14	16	13	18
Q3	2	4	5	4	4.25	5	20.25	20	19	23	18	20	18.5	23
Maximum	5	23	8	11	10	21	48	150	52	102	48	150	52	102
Standard Deviation	0.86	2.96	1.8	1.81	2.27	2.72	8.75	11.61	8.32	9.66	9.57	11.6	7.95	9.67
Number of Days	184	869	32	910	32	903	104	946	107	937	106	947	107	940

Table 2
Change in Volume Due to New Fix

This table reports the mean log volume of traded contracts in the largest futures series for five minute buckets surrounding the old and new fix mechanisms for Silver, Gold, Platinum and Palladium. Old Fix reports the period from the 14th February 2012 to the introduction of the fix for each respective metal. The New Fix reports the period from the first day of the new fix mechanism to the 30th of April, 2015. Before, during and after refer to the 5 minute bucket prior to the start of the fix, the first 5 minutes of the fix and the 5^{th} to 10^{th} minute of the fix, respectively. Each metal which has a morning (AM) and afternoon (PM) fix have results reported separately for each fix. The t-statistics are reported below the means, and document the difference in means between the old and new fix, and the significance of that difference using a two-tailed t-test. Standard errors are clustered both by metal and date. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively.

		Old FIX			New FIX		
Metal & FIX		**Before**	**During**	**After**	**Before**	**During**	**After**
Silver PM	Mean	2.802	3.918	3.271	2.629	3.953	3.140
	T-stat	(-4.30)***	(1.08)	(-3.50)***	(-4.30)***	(1.08)	(-3.50)***
Gold PM	Mean	5.329	6.058	5.624	5.319	6.180	5.743
	T-stat	(-0.15)	(1.81)	(1.64)	(-0.15)	(1.81)	(1.64)
Gold AM	Mean	3.566	4.269	3.675	3.927	4.848	4.045
	T-stat	(5.07)***	(7.88)***	(4.51)***	(5.07)***	(7.88)***	(4.51)***
Platinum PM	Mean	2.145	2.839	2.376	2.366	3.437	2.604
	T-stat	(4.14)***	(13.54)***	(4.51)***	(4.14)***	(13.54)***	(4.51)***
Platinum AM	Mean	1.571	2.047	1.624	1.641	2.330	1.693
	T-stat	(1.11)	(5.13)***	(1.16)	(1.11)	(5.13)***	(1.16)
Palladium PM	Mean	1.679	2.067	1.965	1.585	2.030	2.150
	T-stat	(-1.64)	(-0.66)	(3.56)***	(-1.64)	(-0.66)	(3.56)***
Palladium AM	Mean	1.243	1.494	1.363	1.244	1.481	1.477
	T-stat	(0.02)	(-0.19)	(1.70)	(0.02)	(-0.19)	(1.70)

Table 3

Change in Volatility Due to New Fix

This table reports the mean of Kraus-Satchell volatility estimates for spot contracts for five minute buckets surrounding the old and new fix mechanisms for Silver, Gold, Platinum and Palladium. Old Fix reports the period from the 14th February 2012 to the introduction of the fix for each respective metal. The New Fix reports the period from the first day of the new fix mechanism to the 30th of April, 2015. Before, during and after refer to the 5 minute bucket prior to the start of the fix, the first 5 minutes of the fix and the 5th to 10th minute of the fix, respectively. Each metal which has a morning (AM) and afternoon (PM) fix have results reported separately for each fix. The t-statistics are reported below the means, and document the difference in means between the old and new fix, and the significance of that difference using a two-tailed t-test. Standard errors are clustered both by metal and date. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively.

		Old FIX			**New FIX**		
Metal & FIX		**Before**	**During**	**After**	**Before**	**During**	**After**
Silver PM	Mean	0.0138	0.0185	0.0154	0.0114	0.0173	0.0135
	T-stat	(-8.97)***	(-4.43)***	(-7.49)***	(-8.97)***	(-4.43)***	(-7.49)***
Gold PM	Mean	0.0148	0.0173	0.0155	0.0147	0.0178	0.0155
	T-stat	(-0.23)	(0.91)	(0.06)	(-0.23)	(0.91)	(0.06)
Gold AM	Mean	0.00981	0.0114	0.00970	0.00976	0.0116	0.0101
	T-stat	(-0.22)	(0.80)	(1.58)	(-0.22)	(0.80)	(1.58)
Platinum PM	Mean	0.0105	0.0137	0.0113	0.0116	0.0164	0.0128
	T-stat	(3.47)***	(10.13)***	(5.69)***	(3.47)***	(10.13)***	(5.69)***
Platinum AM	Mean	0.00697	0.00893	0.00686	0.00769	0.0106	0.00752
	T-stat	(1.99)*	(5.04)***	(1.89)	(1.99)*	(5.04)***	(1.89)
Palladium PM	Mean	0.0106	0.0137	0.0126	0.00982	0.0130	0.0138
	T-stat	(-1.74)	(-1.46)	(2.81)**	(-1.74)	(-1.46)	(2.81)**
Palladium AM	Mean	0.00686	0.00882	0.00733	0.00747	0.00941	0.00837
	T-stat	(0.91)	(1.01)	(1.72)	(0.91)	(1.01)	(1.72)

Table 4
Change in Abnormal Returns Due to New Fix

This table reports the mean abnormal returns of contracts in the largest futures series for five minute buckets surrounding the old and new fix mechanisms for Silver, Gold, Platinum and Palladium. Old Fix reports the period from the 14th February 2012 to the introduction of the fix for each respective metal. The New Fix reports the period from the first day of the new fix mechanism to the 30th of April, 2015. Before, during and after refer to the 5 minute bucket prior to the start of the fix, the first 5 minutes of the fix and the 5th to 10th minute of the fix, respectively. Each metal which has a morning (AM) and afternoon (PM) fix have results reported separately for each fix. The t-statistics are reported below the means, and document the difference in means between the old and new fix, and the significance of that difference using a two-tailed t-test. Standard errors are clustered both by metal and date. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively.

		Old FIX			New FIX		
Metal & FIX		**Before**	**During**	**After**	**Before**	**During**	**After**
Silver PM	Mean	-0.231	1.410	0.0915	-0.0922	0.698	-0.291
	T-stat	(0.69)	(-2.65)**	(-1.64)	(0.69)	(-2.65)**	(-1.64)
Gold PM	Mean	0.156	1.688	0.126	0.359	1.257	0.452
	T-stat	(0.45)	(-0.75)	(0.78)	(0.45)	(-0.75)	(0.78)
Gold AM	Mean	0.00876	0.758	-0.00393	-0.0690	0.625	0.0505
	T-stat	(-0.46)	(-0.65)	(0.30)	(-0.46)	(-0.65)	(0.30)
Platinum PM	Mean	0.0398	0.0472	0.0935	0.0906	0.468	-0.0397
	T-stat	(0.22)	(1.42)	(-0.58)	(0.22)	(1.42)	(-0.58)
Platinum AM	Mean	-0.149	-0.228	0.158	-0.215	0.158	-0.204
	T-stat	(-0.26)	(1.64)	(-1.53)	(-0.26)	(1.64)	(-1.53)
Palladium PM	Mean	0.0154	1.177	0.443	-0.0213	1.435	0.266
	T-stat	(-0.09)	(0.61)	(-0.33)	(-0.09)	(0.61)	(-0.33)
Palladium AM	Mean	-0.339	0.0295	0.0711	-0.487	0.945	0.446
	T-stat	(-0.21)	(1.61)	(0.65)	(-0.21)	(1.61)	(0.65)

Table 5
Change in Cumulative Abnormal Returns Due to New Fix

This table reports the mean cumulative abnormal returns of contracts in the largest futures series for five minute buckets surrounding the old and new fix mechanisms for Silver, Gold, Platinum and Palladium. Old Fix reports the period from the 14th February 2012 to the introduction of the fix for each respective metal. The New Fix reports the period from the first day of the new fix mechanism to the 30th of April, 2015. Before, during and after refer to the 5 minute bucket prior to the start of the fix, the first 5 minutes of the fix and the 5th to 10th minute of the fix, respectively. Each metal which has a morning (AM) and afternoon (PM) fix have results reported separately for each fix. The t-statistics are reported below the means, and document the difference in means between the old and new fix, and the significance of that difference using a two-tailed t-test. Standard errors are clustered both by metal and date. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively.

		Old FIX			New FIX		
Metal & FIX		**before**	**During**	**After**	**Before**	**During**	**After**
Silver PM	Mean	-1.128	7.039	0.454	-0.444	3.456	-1.440
	T-stat	(0.63)	(-2.46)*	(-1.66)	(0.63)	(-2.46)*	(-1.66)
Gold PM	Mean	0.779	8.433	0.628	1.797	6.286	2.261
	T-stat	(0.40)	(-0.61)	(0.88)	(0.40)	(-0.61)	(0.88)
Gold AM	Mean	0.0404	3.555	-0.0181	-0.345	3.127	0.252
	T-stat	(-0.48)	(-0.51)	(0.28)	(-0.48)	(-0.51)	(0.28)
Platinum PM	Mean	0.174	0.227	0.432	0.440	2.331	-0.196
	T-stat	(0.28)	(1.39)	(-0.60)	(0.28)	(1.39)	(-0.60)
Platinum AM	Mean	-0.512	-0.900	0.547	-0.775	0.674	-0.761
	T-stat	(-0.33)	(1.51)	(-1.66)	(-0.33)	(1.51)	(-1.66)
Palladium PM	Mean	0.0561	4.992	1.866	-0.0796	6.383	1.223
	T-stat	(-0.10)	(0.76)	(-0.38)	(-0.10)	(0.76)	(-0.38)
Palladium AM	Mean	-0.803	0.0838	0.197	-1.122	2.632	1.299
	T-stat	(-0.23)	(1.69)	(0.86)	(-0.23)	(1.69)	(0.86)

Table 6

Impact of the new fix mechanisms on the fix start

This table reports the results of a panel regression for each dependent variable in either the first five or ten minutes of the PM fix for futures contracts over Silver, Gold, Platinum and Palladium. Data from the 14th February 2012 to the 30th April 2015 is utilized. A dummy variable is introduced for the new fix mechanism employed for each metal. Dummy variables for each of the metals are also utilized, with palladium forming the base case. VIX is a daily measure of the volatility index. The t-statistics are reported below the means, and document the difference in means between the old and new fix, and the significance of that difference using a two-tailed t-test. Standard errors are clustered both by metal and date. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively.

	First 5 minutes				First 10 minutes			
Variable	**Volume**	**Volatility**	**AR**	**CAR**	**Volume**	**Volatility**	**AR**	**CAR**
Silver New Fix	0.000	-0.001*	-0.548**	-2.732**	-0.063	-0.001***	-0.474**	-4.443**
	(0.002)	(-1.871)	(-1.987)	(-2.052)	(-1.255)	(-3.077)	(-2.474)	(-2.478)
Gold New Fix	0.104	0.001	-0.226	-1.237	0.124	0.001	0.072	0.582
	(0.848)	(1.257)	(-0.327)	(-0.357)	(1.043)	(1.106)	(0.185)	(0.150)
Platinum New Fix	0.608***	0.003***	0.551*	2.623*	0.434***	0.003***	0.228	2.102
	(10.067)	(8.102)	(1.811)	(1.734)	(8.056)	(7.606)	(1.237)	(1.157)
Palladium New Fix	-0.030	-0.000	0.424	1.920	0.099*	0.001*	0.086	1.393
	(-0.447)	(-0.502)	(1.023)	(1.048)	(1.957)	(1.913)	(0.343)	(0.626)
Silver	1.898***	0.005***	0.230	1.958**	1.612***	0.004***	-0.068	0.534
	(60.279)	(18.956)	(1.162)	(2.252)	(57.411)	(17.327)	(-0.555)	(0.482)
Gold	4.032***	0.004***	0.550***	3.533***	3.860***	0.004***	0.115	2.321**
	(128.833)	(16.145)	(3.148)	(4.755)	(138.300)	(17.416)	(1.028)	(2.351)
Platinum	0.793***	0.000	-1.125***	-4.755***	0.608***	-0.001***	-0.749***	-6.180***
	(24.380)	(0.829)	(-6.409)	(-6.505)	(22.497)	(-2.597)	(-6.689)	(-6.379)
VIX	-0.008***	0.000***	0.074***	0.329***	0.000	0.000***	0.045***	0.397***
	(-3.852)	(10.916)	(5.087)	(5.129)	(0.049)	(12.692)	(5.245)	(5.053)
Intercept	2.168***	0.010***	-0.239	-1.248	1.976***	0.009***	-0.041	-0.669
	(47.752)	(26.270)	(-0.872)	(-0.995)	(48.598)	(27.186)	(-0.248)	(-0.429)
Observations	4,076	4,076	4,076	4,076	4,077	4,077	4,077	4,077
Adjusted R2	0.833	0.193	0.040	0.045	0.850	0.212	0.033	0.033

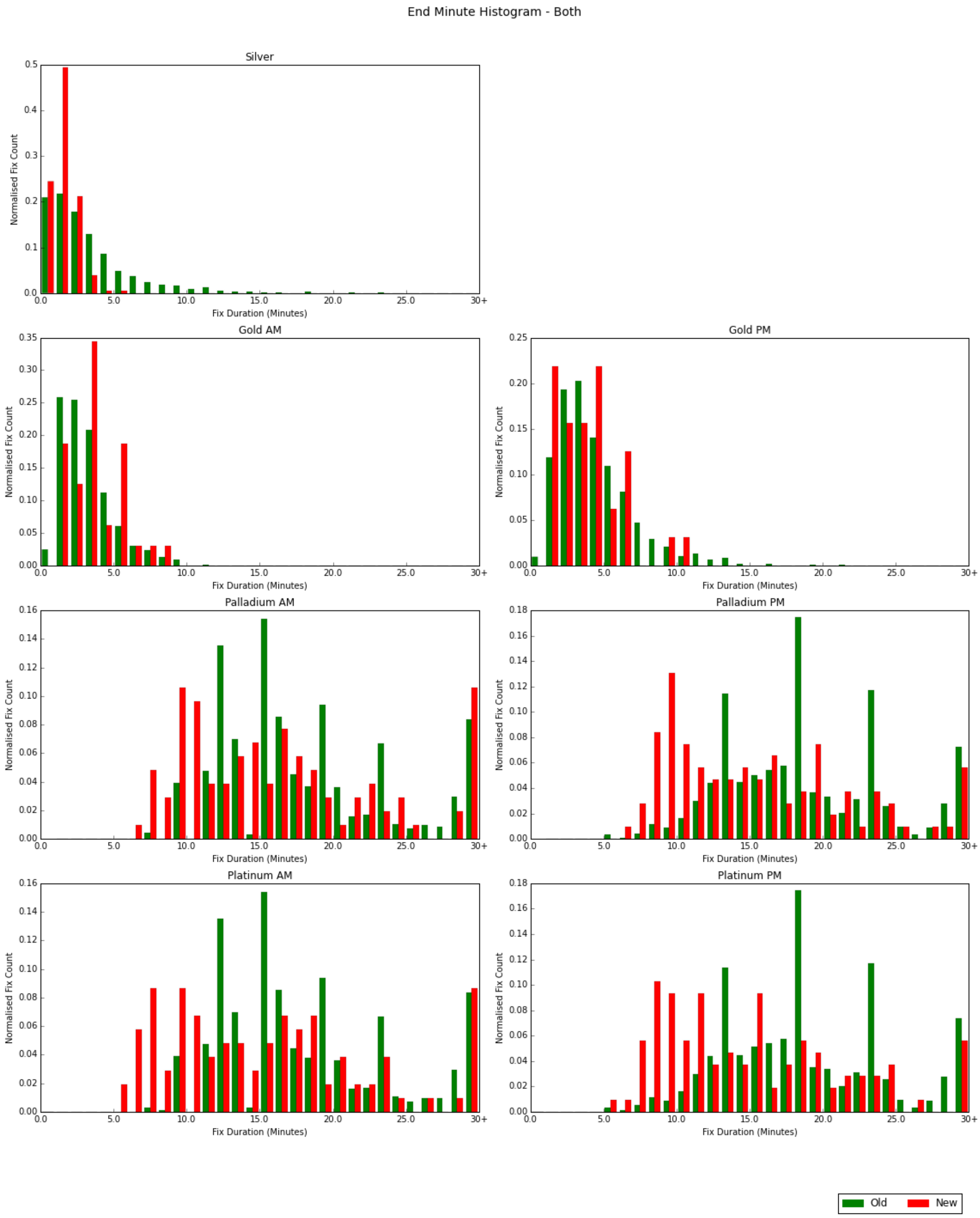

Figure 1. Distribution of Fix Durations
This histogram shows the distribution of the durations of the Fix per metal for each of the morning (AM) and afternoon (PM) fixes. The durations of both the old and new mechanisms are shown side by side.

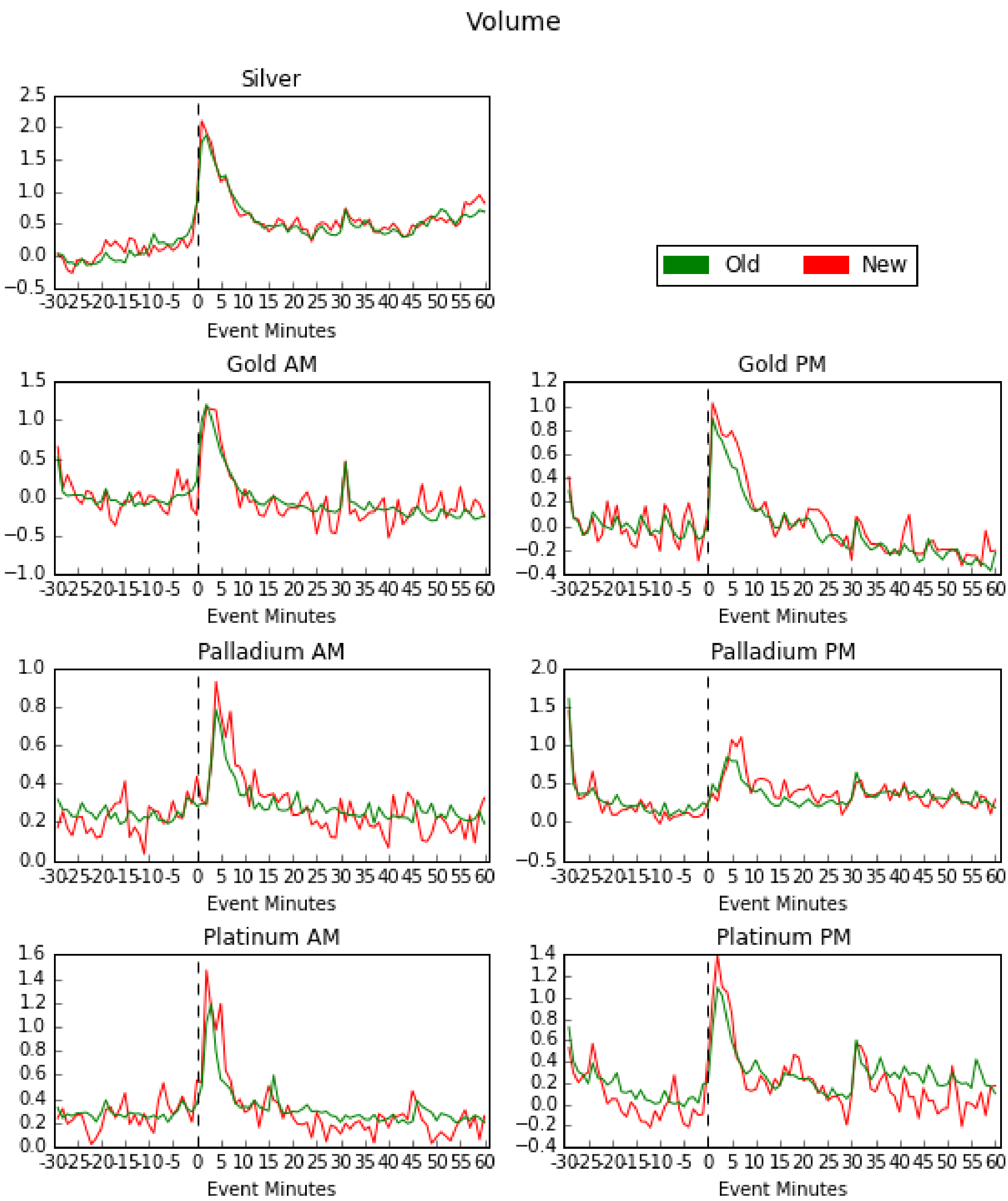

Figure 2. Volume traded at the start of the fix

These graphs report the natural log of the number of futures contracts traded in the 90 minutes surrounding the start of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the start of the fix period.

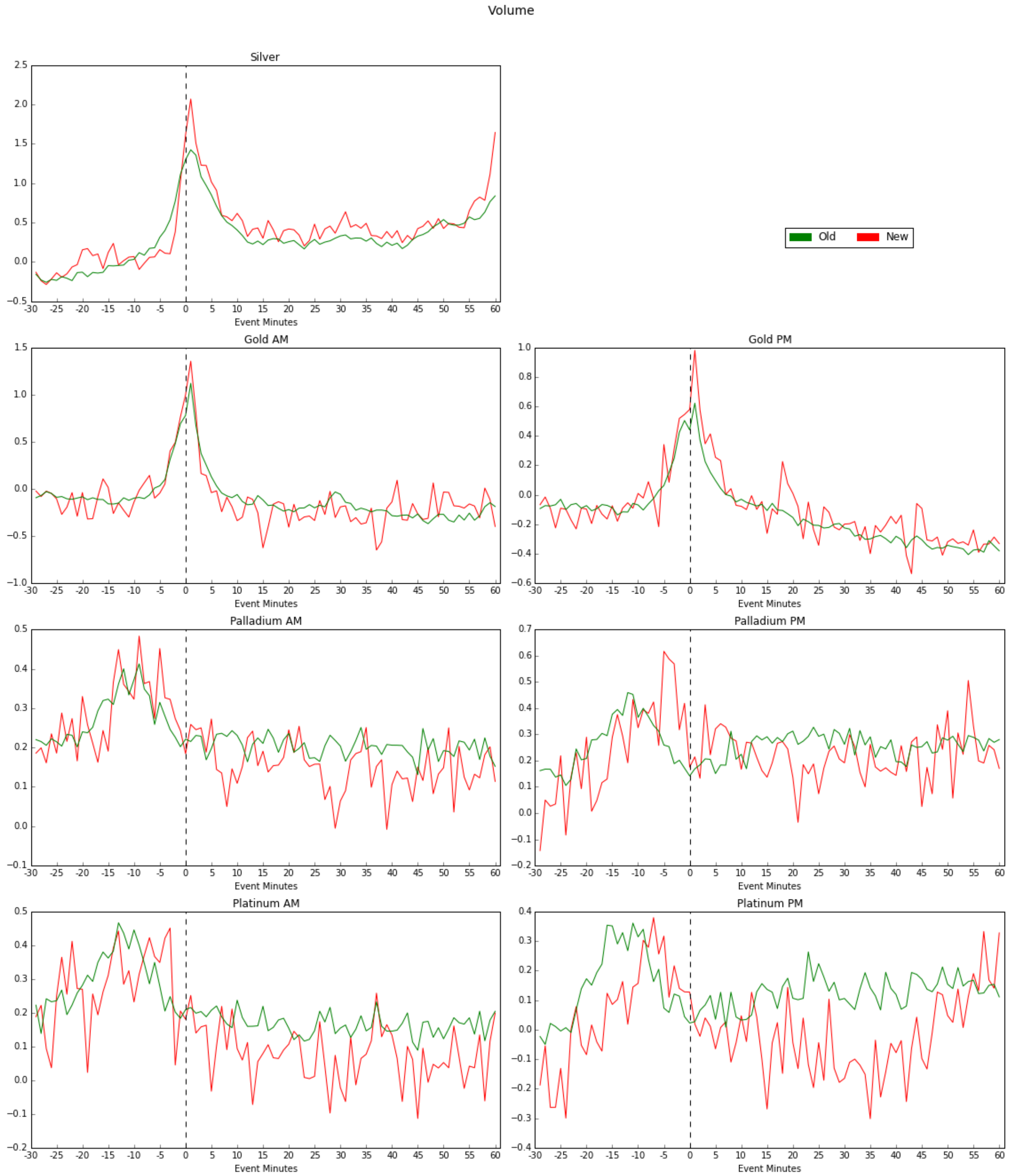

Figure 3. Volume traded at the end of the fix
These graphs report the natural log of the number of futures contracts traded in the 90 minutes surrounding the end of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the end of the fix period.

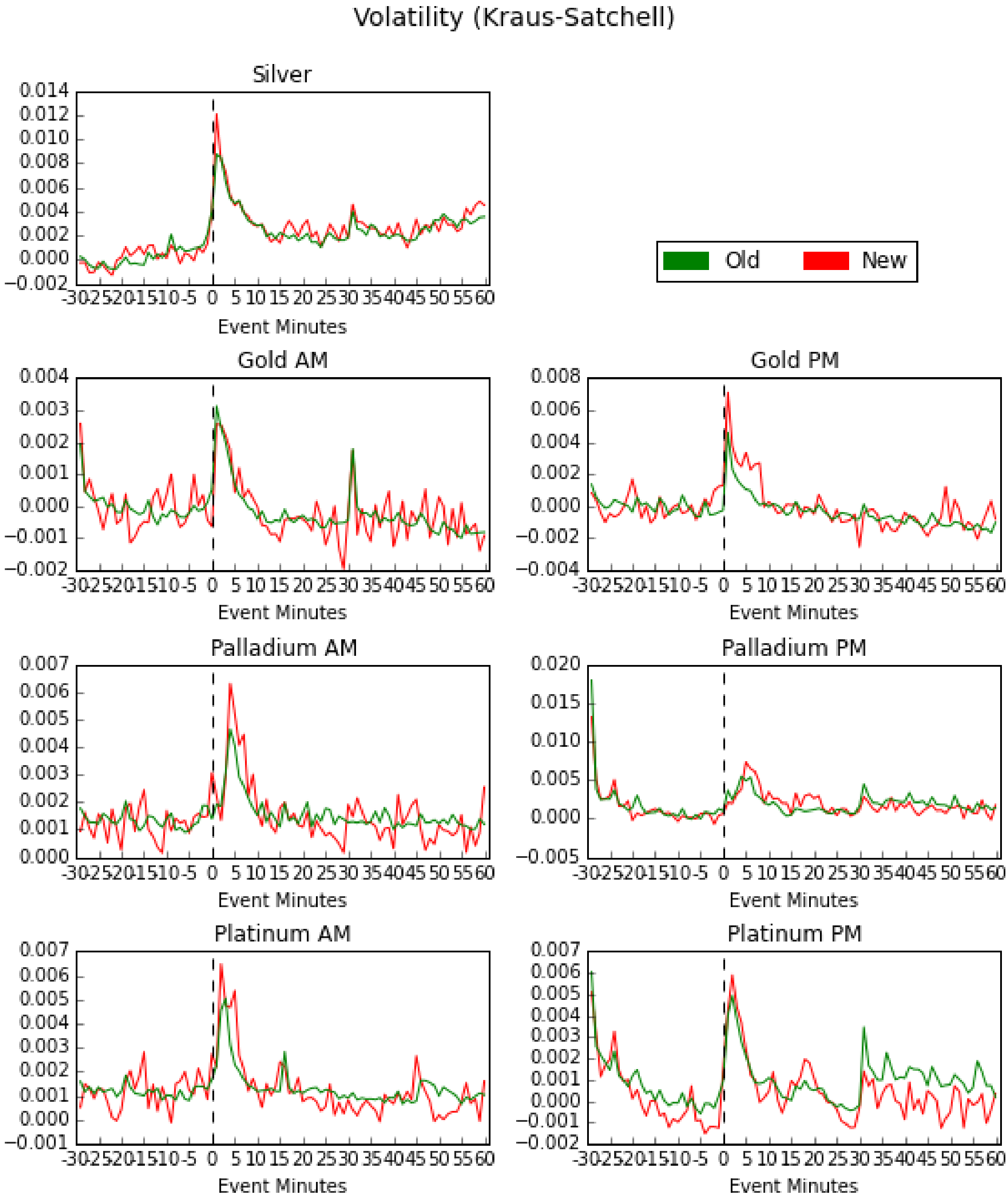

Figure 4. Volatility at the start of the fix

These graphs report the Kraus-Satchell volatility measure for futures contracts traded in the 90 minutes surrounding the start of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the start of the fix period.

Figure 5. Volatility at the end of the fix

These graphs report the Kraus-Satchell volatility measure for futures contracts traded in the 90 minutes surrounding the end of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the end of the fix period.

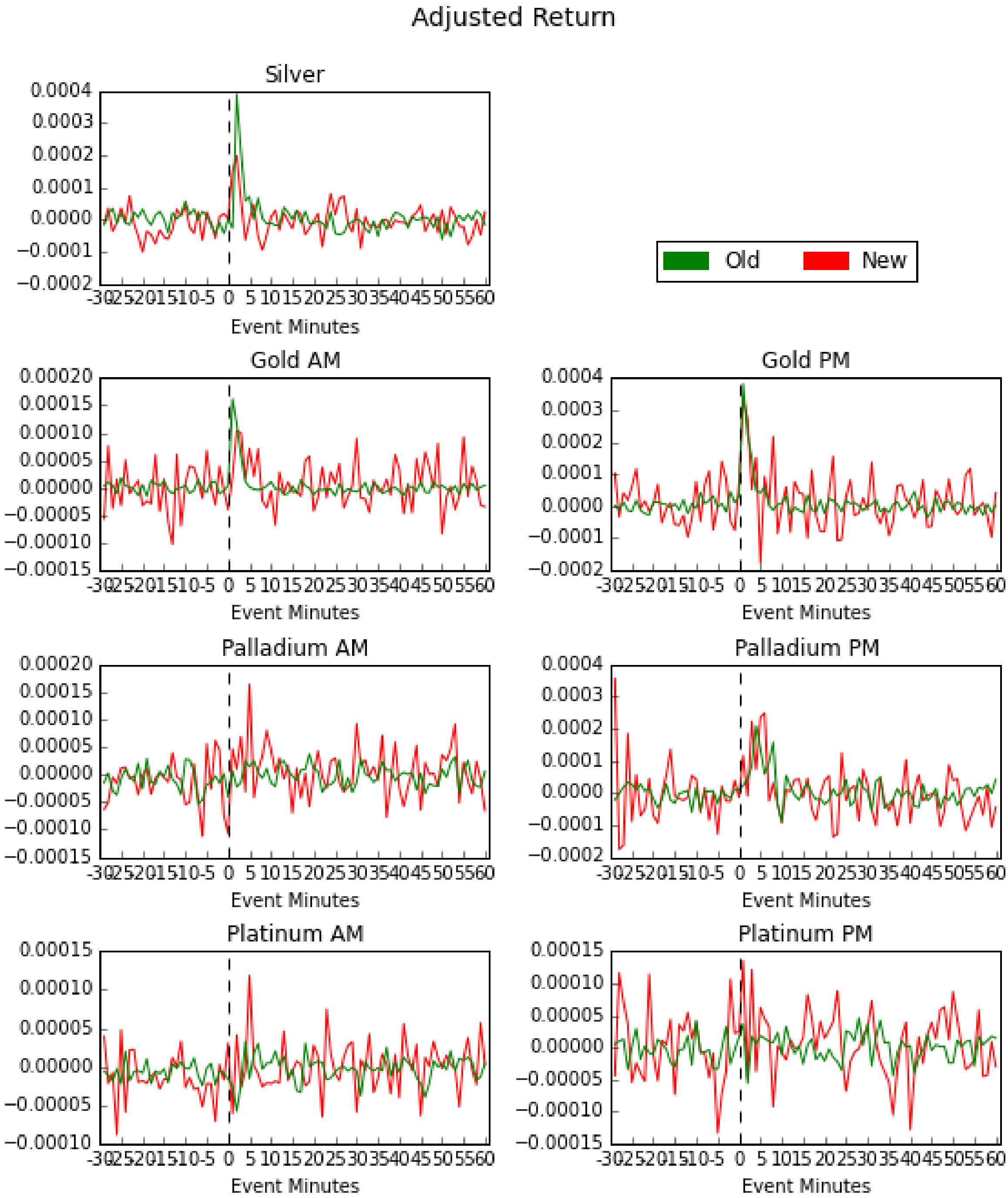

Figure 6. Abnormal returns at the start of the fix
These graphs report the abnormal returns for futures contracts traded in the 90 minutes surrounding the start of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the start of the fix period.

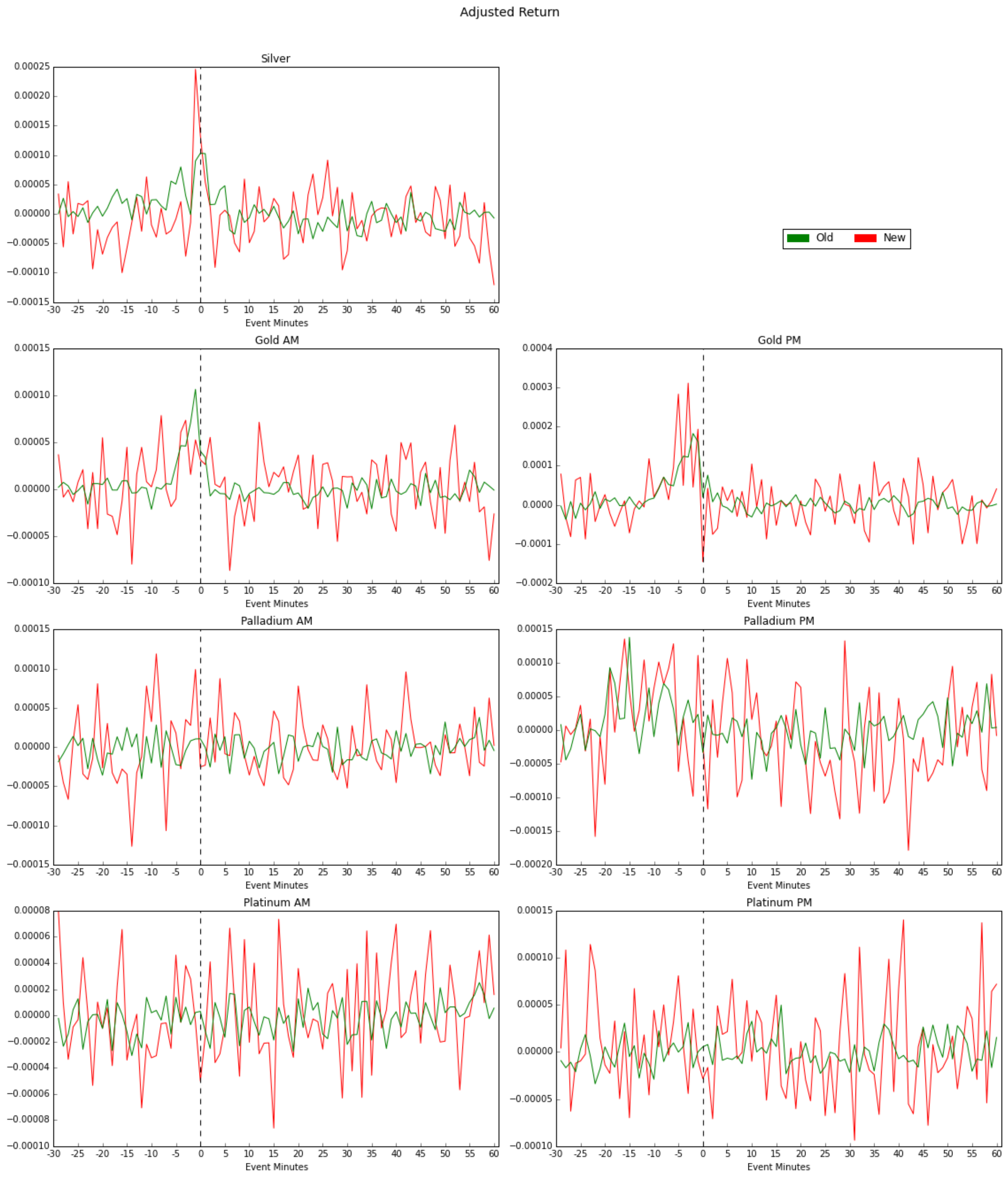

Figure 7. Abnormal returns at the end of the fix
These graphs report the abnormal returns for futures contracts traded in the 90 minutes surrounding the end of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the end of the fix period.

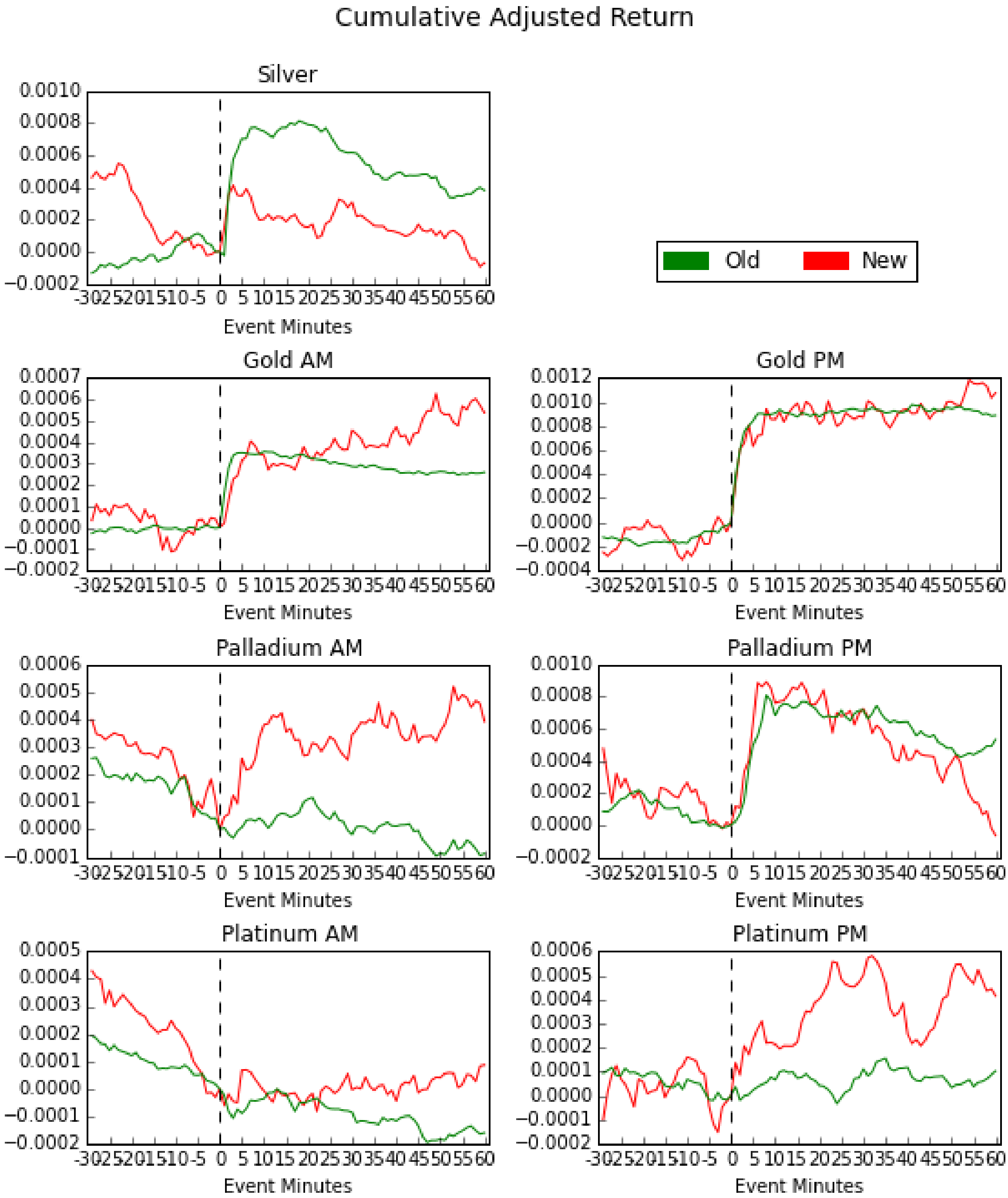

Figure 8. Cumulative abnormal returns at the start of the fix

These graphs report the cumulative abnormal returns for futures contracts traded in the 90 minutes surrounding the start of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the start of the fix period.

Figure 9. Cumulative abnormal returns at the end of the fix
These graphs report the cumulative abnormal returns for futures contracts traded in the 90 minutes surrounding the end of the fix under both the old and new fix mechanisms. The vertical line at time 0 represents the end of the fix period.